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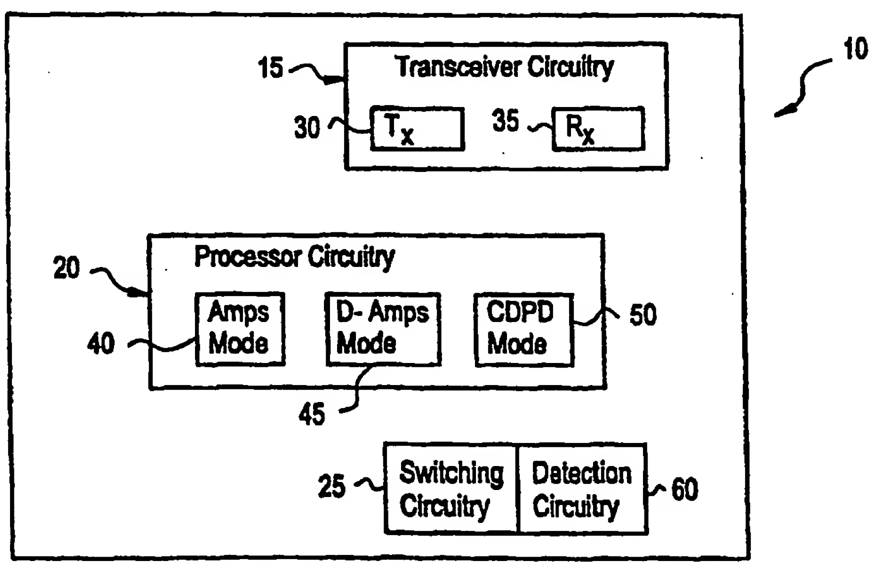
(54) Title: TRIPLE MODE CELLULAR PHONE




(57) Abstract

A cellular radio telephone (10) capable of operating within at least three separate cellular communications protocols is disclosed. Transceiver circuitry (15) capable of transmitting and receiving signals within the three cellular communications protocols are responsive to control signals from a processing apparatus (20) that controls the circuitry (15) according to either a AMPS (40), D-AMPS (45) or CDPD (50) cellular communications protocol. Selection between the various cellular communications protocols controlled by the processor (20) is responsive to a user actuated input or automatic switches to the proper protocol in response to detection of location of the cellular radio telephone (10) within a coverage area served by a particular cellular communications protocol.

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# TRIPLE MODE CELLULAR PHONE

## BACKGROUND OF THE INVENTION

### Technical Field of the Invention

The present invention relates to hand-held cellular telephones, and more particularly, to a hand-held cellular telephone capable of operating according to at least three different cellular communication protocols.

### Description of Related Art

The development of cellular telephone technology has lead to the creation of various types of cellular communications protocols which are not compatible with each other. The advanced mobile phone systems (AMPS) standard is a system developed utilizing analog communications techniques. AMPS systems provide widespread coverage but are fragmented in various locations throughout the country. AMPS is currently the most widely-used air interface standard in the United States and utilizes an analog cellular communications protocol for transmitting voice data using frequency modulation. The AMPS air interface occupies the 824.04 MHz to 891.51 MHz frequency range. The base station transmit and receive bands in an AMPS system are separated by 45 MHz with a 30 kHz channel spacing.

The Digital American Mobile Phone System (D-AMPS) standard was developed utilizing a digital rather than an analog air interface between the mobile cellular telephone and their associated base stations. D-AMPS is a newer technology providing the potential for much higher data rates and is similar to the GSM standard utilized in Europe.

Another newly-developed technology entitled cellular digit packet data (CDPD) utilizes packet data transmissions for transferring information data, rather than voice data, between a mobile cellular telephone and its associated base station. CDPD is a packet switching system utilizing idle voice channels from a cellular system band to carry data traffic. A CDPD system may be assigned to a dedicated channel or used between idle channels.

With various systems, such as those mentioned above, providing a variety of coverage areas within a particular geographic location, a user traveling extensively between various coverage areas may find himself served by a communications protocol that their phone is not programmed to handle. Thus, a mobile cellular telephone terminal capable of operating according to a variety of cellular communications protocols such as AMPS, D-AMPS, and CDPD, would greatly benefit users who travel extensively.

SUMMARY OF THE INVENTION

The present invention overcomes the foregoing and other problems with the cellular telephone capable of operating according to at least three cellular communications protocols. The cellular telephone includes transceiver circuitry for transmitting and receiving cellular communication signals. The transceiver circuitry is capable of operating according to at least three cellular communication protocols, and in a preferred embodiment, the AMPS, D-AMPS and CDPD cellular communications protocols. The transceiver circuitry is controlled by processing circuitry which enables the same transceiver circuitry to be utilized to process signals according to AMPS, D-AMPS or CDPD communications protocol requirements.

Selections between the various communications protocols are made by a switching means that may be manually actuated by the user, or alternatively, may be responsive to a determination by the cellular telephone that the unit is located within a coverage area served by a particular cellular communications protocol to automatically switch to the protocol detected by the unit.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is made to the following detailed description taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a functional block diagram of the triple mode phone;

FIGURE 2 is a functional block diagram of the transmission circuitry;

FIGURE 3 is a functional block diagram of the receiver circuitry; and

FIGURE 4 is a schematic diagram of the transceiver circuitry.

## DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, and more particularly to FIGURE 1, there is illustrated a functional block diagram of the triple mode phone. The triple mode phone 10 includes transceiver circuitry 15, processor circuitry 20, and switching circuitry 25. The transceiver circuitry 15 includes transmission circuitry 30 and receiver circuitry 35 for providing full duplex transmission and reception of signals between the triple mode phone and a wireless base station. The same circuitry is utilized for both transmission and reception of analog and digital voice information and packet data information. One embodiment of the transceiver circuitry 15 will be more fully discussed with respect to FIGURE 4.

The processor circuitry 20 includes processing functionalities necessary for carrying out three separate modes of operation for the triple mode phone. The AMPS mode 40 provides for analog communications between the triple mode phone 10 and a base station at 4.8 kbps using the AMPS cellular communications protocol. The D-AMPS mode 45 provides for 9.6 kbps digital voice transmissions from the triple mode phone 10 using the D-AMPS cellular communications protocol. Finally, the CDPD mode 50 provides for a 19.2 kbps packet switched data functionality for transmitting user data rather than voice data from the triple mode phone 10 to a base station transceiver using the CDPD cellular communications protocol. Each of the various modes merely comprises a different software functionality that controls the transceiver circuitry 15 of the triple mode phone 10. Thus, depending on which mode is controlling the transceiver circuitry 15, the transmission bit rates will be altered accordingly.

A switching circuitry 25 enables switching between the various modes of the triple mode phone 10. In a preferred embodiment, the switching circuitry 25 includes detection circuitry 60 for determining by which communications protocol the triple mode phone 10 is currently served. For example, the detection circuitry 60 would determine whether the phone 10 is located within an AMPS, D-AMPS, or CDPD coverage area, and in response to this determination, the phone would automatically

switch to the appropriate mode of operation and enable transmission and reception of signals according to the desired protocol. Furthermore, the switching circuitry may be manually activated such that a user may manually initiate operation of a particular protocol necessary for successful operation.

FIGURE 2 illustrates a functional block diagram of the transmit path for a triple mode phone 10. PCM digital data representing the voice or user data is received at a transmit digital signal processor (DSP) 144 within the processor circuitry 20. The DSP 144 performs gain control, filtering, digital voice coding, area correction coding, and burst data formatting, and transmits the results to the transmit interface 120 to be formed into a correct I&Q signals for modulation by modulator 115. In analog mode, the 8K samples per second PCM voice data are not reduced by speech coding or subjected to error correction coding. Instead, a digital implementation of the AMPS specified 2:1 dynamic range companding algorithm is employed. Samples of the companded waveform are then converted to a frequency modulation waveform and from that to phase samples and ultimately I,Q waveforms.

The I&Q signals are applied to a pair of mixers in modulator 115 with an in-phase and 90° out-of-phase signal fed in from phase shifter 114 at a transmit intermediate frequency. These are summed and mixed up to the selected channel frequency at mixer 116 to be transmitted through a duplexer 100. In an alternative implementation, the up mixer produces an unmodulated carrier frequency which is then I,Q modulated with the I,Q waveforms.

FIGURE 3 is an illustration of the receiver path. The received signal comes through duplexer 100 and is mixed down from the selected channel frequency at a mixer 103 to a first IF frequency using a synthesized local oscillator signal. The receiver chip 106 mixes and filters the signal down to a second IF frequency, with the assistance of the synthesizer 110 and reference oscillator 112, the second IF signal then being sampled by the receiver interface section 80. The interface section 80 converts the second IF signal to a series of phase samples. The phase, amplitude and frequency samples are forwarded to the receiver DSP 142 of the processor circuitry 20 for processing. The receiver DSP 142 performs demodulation, filtering, gain attenuation, and in digital mode, channel decoding and speech decompression.

In the present invention, a software change and some hardware operating mode changes are all that are necessary to switch between analog, digital and packet switched modes. The main difference between the three modes are the rates at which the transmit and receive interface is run and the type of software running the receiver and transmitter digital signal processors. Each time a mode change is required, the processor circuitry 20 commands the hardware interfaces to change rates and download a different set of software to the DSPs. One DSP 144 performs all transmit functions while a second DSP 142 performs all receive functions.

Referring now to FIGURE 4 there is provided a description of one embodiment of the transceiver circuitry 15. A common antenna 99 transmits and receives RF signals. A duplexer 100 enables full duplex operation by separating the transmit and receive signal paths. The transmitter circuitry 30 includes a multiplier 113, an I/Q modulator 115, a mixer 116, a channel synthesizer 110, and a power amplifier 117. The transmitter circuitry 30 operates over a frequency range of 824.04 MHz to 848.97 MHz in the preferred embodiment. Modulation is accomplished at the I/Q modulator 115, whose carrier frequency is supplied by the output, e.g., 116.64 MHz, of the multiplier 113. The transmit frequency is generated by mixing the output of the channel synthesizer 110, as modified by a buffer amplifier 111, and the output of the I/Q modulator 115. The signal is then amplified, through a gain controlled stage 117a and filtered at TX filter 117b before being coupled into the linear power amplifier 117c.

The transmitter intermediate frequency TX IF of 116.64 MHz is generated by multiplying, via the multiplier 113, a reference signal from a reference signal generator or oscillator 112 by a factor of 6.

The receiver circuitry 35 operates over the frequency range of 869.04 MHz to 893.97 MHz, and may be a dual conversation superheterodyne receiver with a 71.04 MHz first intermediate frequency (IF), and a 600 kHz second IF. The channel synthesizer 110 provides the high side, first local oscillator frequency injection to the receiver circuitry 35. The channel synthesizer 110 tunes the range of 940.68 MHz to 965.61 MHz in 30 kHz steps.

The receiver circuitry 35 includes a RF amplifier 101, a RF bandpass filter 102, a first mixer 103, a 71.04 MHz crystal filter 104, a second mixer/amplifier/oscillator

circuit 106, and two second IF filters 107, 108. The RF input signal from the antenna enters the receiver through the duplexer 100. The signal is supplied to the RF amplifier 101, where it is amplified by approximately 16dB. The signal is then applied to the input of the receiver filter 102. The duplexer 100 and the filter 102 provide first image rejection, limit conduction of the channel synthesizer frequency to the antenna port, and protect the receiver from being over-driven by the transmit signal.

The output of the receiver filter 102 is supplied to the first mixer 103 where it is mixed with the signal from the channel synthesizer 110 supplied through a buffer amplifier 111 and filter 105. The mixer output is applied to the first IF filter 104. The filter output is applied to a mixer/amplifier/oscillator circuit 106 where it is down converted at block 106b to 600 kHz. After the down conversion the signal is filtered by two filters 107 and 108 and amplified by multi-stage amplifiers 106c and 106d.

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it is understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A radio telephone comprising:

transceiver circuitry for transmitting and receiving signals;

processing means for controlling the transceiver circuitry to process signals according to at least three separate communications protocols; and

means for switching between the at least three separate communications protocols.

2. The radio telephone of Claim 1 wherein the at least three separate communications protocols comprise AMPS, D-AMPS and CDPD.

3. The radio telephone of Claim 1 wherein the means for switching enables manual switching between the at least three separate communications protocols.

4. The radio telephone of Claim 1 wherein the means for switching automatically switches between the at least three communications protocols in response to a determination that the radio telephone resides within a coverage area served by one of the at least three communications protocols.

5. A radio telephone comprising:

transceiver circuitry for transmitting and receiving signals;

processing means for controlling the transceiver circuitry to process signals according to AMPS, D-AMPS and CDPD cellular communications protocol; and

means for switching automatically between the AMPS, D-AMPS and CDPD cellular communications protocol in response to a determination that the radio telephone resides within a coverage area served by one of these cellular communications protocols.

6. The radio telephone of claim 5 wherein the means for switching enables manual switching between the AMPS, D-AMPS and CDPD cellular communications protocol.

7. The radio telephone of Claim 5 wherein the means for switching automatically switches between the at least three communications protocols in response to a determination that the radio telephone resides within a coverage area served by one of the at least three communications protocols.

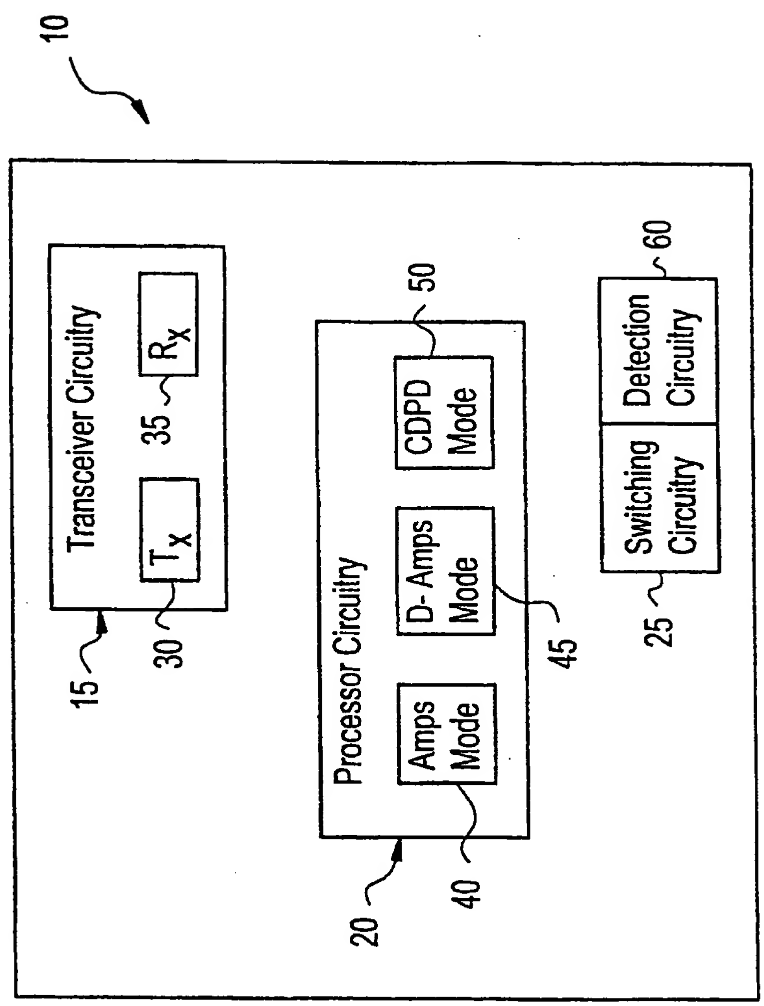

10
Transceiver Circuitry
$T_X$
$R_X$
15
30
35
Processor Circuitry
Amps Mode
D-Amps Mode
CDPD Mode
20
40
45
50
Switching Circuitry
Detection Circuitry
25
60

FIG. 1

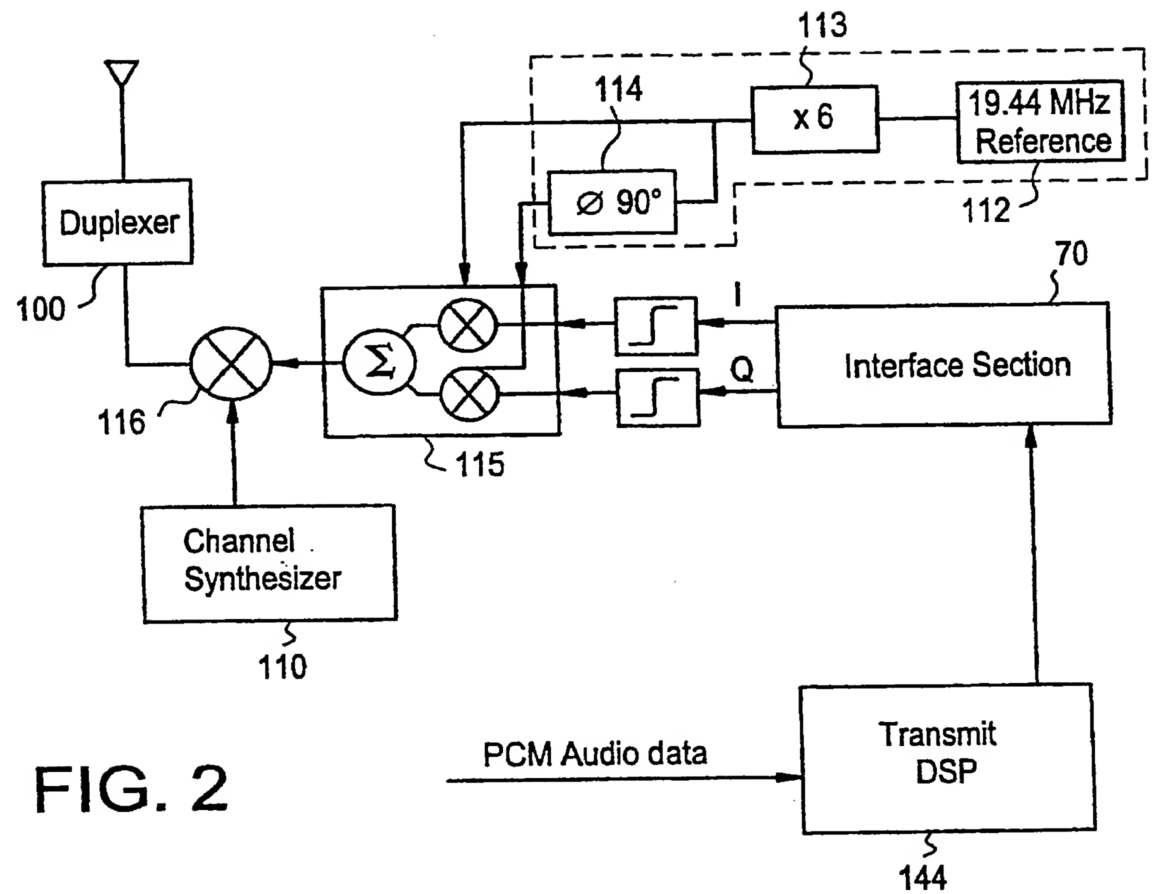

113
114
x 6
19.44 MHz
Reference
Duplexer
Ø 90°
112
70
100
I
Σ
Interface Section
Q
116
115
Channel
Synthesizer
110
PCM Audio data
Transmit
DSP
144

FIG. 2

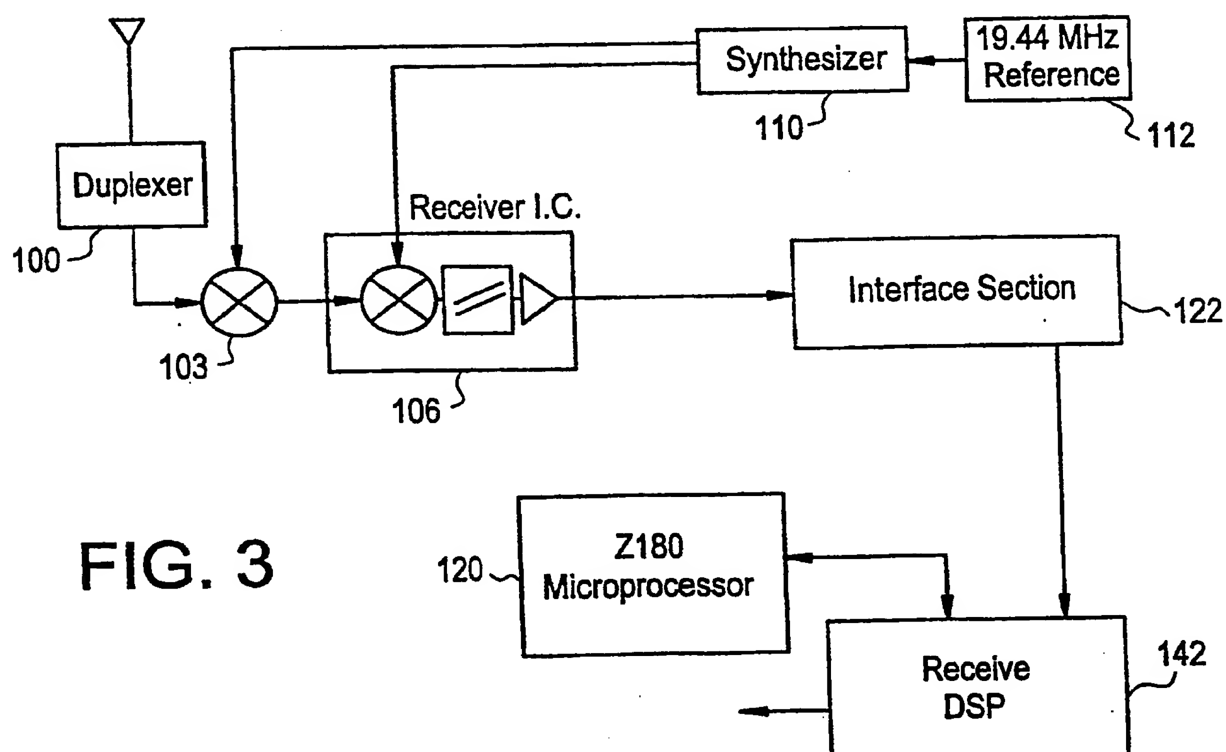
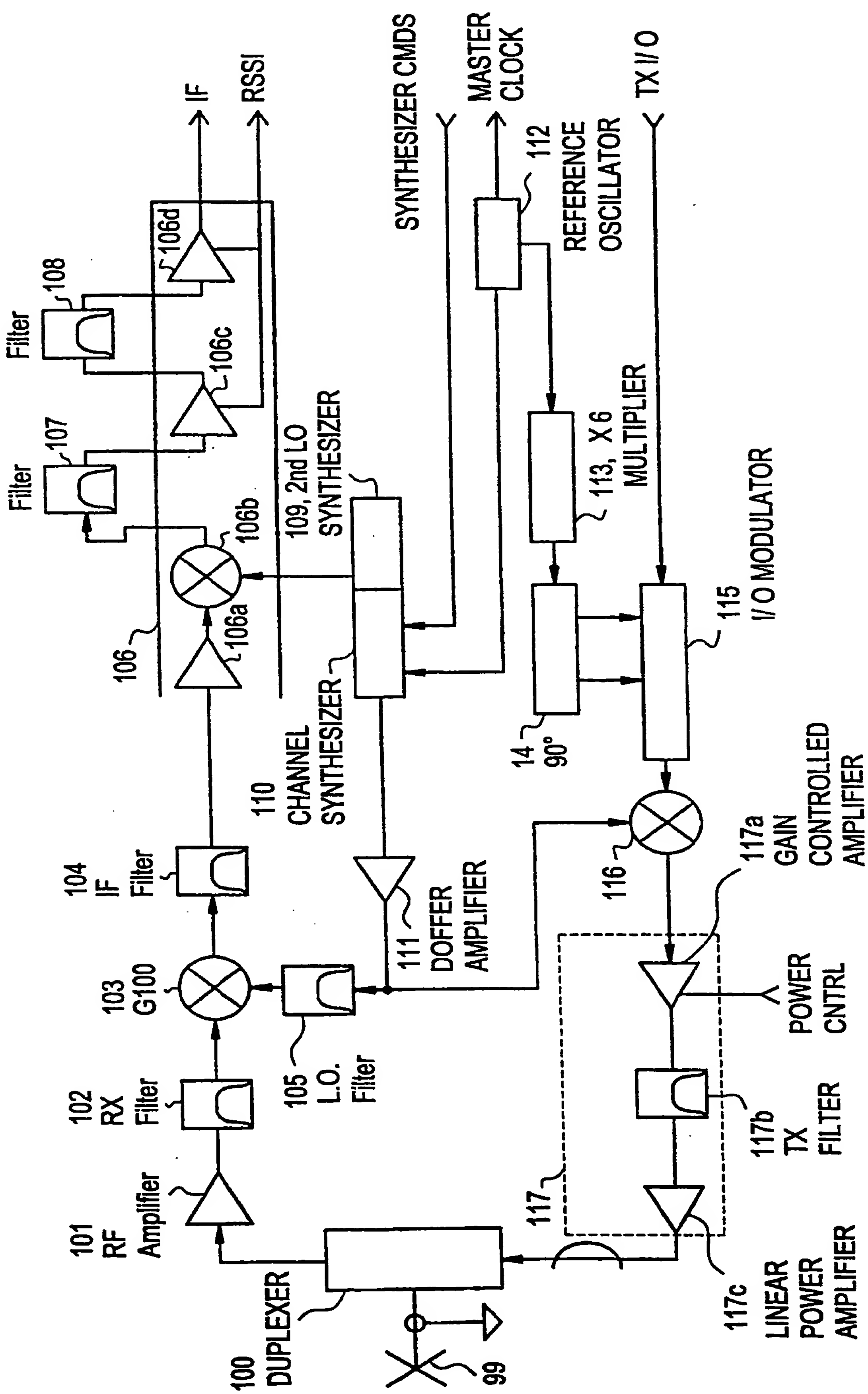

Synthesizer
19.44 MHz
Reference
110
112
Duplexer
Receiver I.C.
100
Interface Section
122
103
106
Z180
Microprocessor
120
142
Receive
DSP

FIG. 3

FIG. 4


IF
RSSI
SYNTHESIZER CMDS
MASTER CLOCK
TX I/O
Filter
108
106d
Filter
107
106c
106b
106
106a
109, 2nd LO SYNTHESIZER
112
REFERENCE OSCILLATOR
113, X 6 MULTIPLIER
I/O MODULATOR
115
I/O MODULATOR
14
90°
110
CHANNEL SYNTHESIZER
104
IF
Filter
103
G100
111
DOFFER AMPLIFIER
116
117a
GAIN CONTROLLED AMPLIFIER
POWER CNTRL
102
RX
Filter
105
L.O.
Filter
117b
TX
FILTER
101
RF
Amplifier
117
117c
LINEAR POWER AMPLIFIER
100
DUPLEXER
99

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 98/01137

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 H04Q7/32

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Int. tional Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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